PROXIMATE COMPOSITION OF *Sida acuta* LEAF EXTRACT

BY

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CERTIFICATION

This is to certified that this work is the original work of Aare Kafayat Omowunmi with Matric N0. HND/23/SLT/FT/1029, carried out and has been read and approved as meeting the requirements in Partial Fulfillment for the award of Higher National Diploma (HND) in Science Laboratory Technology (Biochemistry Option), and submitted to the Department of Science Laboratory Technology (SLT), Institute of Applied Sciences (IAS), Kwara State Polytechnic, Ilorin.

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DEDICATION

This project work is dedicated to Almighty God and to my parents.

ACKNOWLEDGEMENTS

Alhamdulillah, all praise and adoration goes to the most high, Almighty Allah who has been sustaining me and giving me the courage and strength to face the challenge of my academic pursuit and for making the completion of this course a reality. I also acknowledge our noble prophet Mohammed (S.A.W) his house hold and his companionship till d day of resurrection.

My profound gratitude goes to my amiable supervisor in person of Dr. Mrs. Hassan I.R. for her full support towards the success of this work, and to the HOD, Dr. Usman Abdulkareem and also to the HOU, the person of Mrs. Salaudeen K.A. may you never stumble (Amen) and also to the entire lecturer in the Department of SLT may Almighty Allah bless you all. Jazakumullah khairan.

I am expressing unrepentantly appreciation to my parent most especially my mum for her parental support, advice and prayers. I pray to Almighty Allah to make you reap the fruit of your Labour and may he make you live long enough to enjoy our greatness in life with good health.

My sincere appreciation goes to my Dad the person of Aare Akeem. I really appreciate your support both financially and spiritually, l pray to Almighty Allah to make you reap the fruit of your Labour and may he make you live long enough to enjoy our greatness in life with good health.

I cannot forget the effort of my blood brothers Aare Afeez and Aare Ridiwan for the support. You are one in a million, and to my sisters, Aare Risiwat and Aare Mutiat I really love you guys and to all my family members I appreciate you all.

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ABSTRACT

Sida acuta is a fast-growing, herbaceous shrub commonly found in tropical and subtropical regions. Traditionally used in African and Asian folk medicine for treating ailments such as fever, wounds, inflammation, and infections, the plant has attracted growing scientific interest due to its potential therapeutic and nutritional properties. Despite its widespread use, limited empirical data exist on its comprehensive nutritional profile, particularly its proximate composition, which is essential for validating its value in food, herbal, and animal feed applications. This study addresses this knowledge gap by evaluating the proximate composition of Sida acuta to determine its nutritional significance and suitability for broader applications. Two dried leaf samples (A1 and A2) were analyzed for moisture, crude protein, crude lipid, ash, crude fibre, and carbohydrate contents using standard analytical procedures. The results revealed low moisture content (A1: 8.08%, A2: 8.40%), which supports good shelf stability and resistance to microbial spoilage. Crude protein values were moderate (13.56% and 13.78%), indicating the plant's potential as a supplementary protein source. Crude lipid levels (7.07% and 7.21%) were relatively high for a leafy plant, providing additional caloric and fat-soluble nutrient benefits. Ash content was significantly high (11.39% and 11.44%), suggesting a rich mineral composition, while the very high crude fibre content (29.22% and 27.52%) highlights its role in digestive health. Carbohydrates were the most abundant macronutrient (30.68% and 31.64%), positioning Sida acuta as an energy-rich plant material. Overall, the findings demonstrate that Sida acuta is not only medicinally important but also nutritionally valuable. It has the potential to be utilized in human diets, phytomedicinal preparations, and animal feed formulations. Further phytochemical and pharmacological studies are recommended to explore and harness its full potential.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Sida acuta, a hardy shrub belonging to the Malvaceae family, is one such plant under scientific scrutiny. Though traditionally regarded as a weed, its widespread presence and versatility suggest that it could be a viable option for nutritional and medicinal applications.The study of proximate composition is a foundational method in nutritional science, providing essential data about the basic components of a food or plant material. It determines the content of water (moisture), ash (mineral residue), proteins, lipids (fats), crude fiber, and carbohydrates. These values are critical indicators of a plant's dietary potential and its applicability in food technology, pharmacognosy, and feed formulation (Aremu *et al*., 2011). When applied to plants like *Sida acuta*, proximate analysis not only helps quantify its nutritional potential but also reveals its limitations and areas needing further processing or enrichment.

Historically, *Sida acuta* has been used in traditional medicine systems across Asia, Africa, and Latin America. Ethnobotanical studies have documented its use in treating ailments such as wounds, ulcers, fever, and gastrointestinal disorders (Aliyu *et al*., 2007; Odugbemi, 2006). Phytochemical screenings confirm the presence of biologically active compounds, including alkaloids, flavonoids, and tannins, which provide therapeutic benefits. However, nutritional studies are less common, and those that exist often vary in methodology and scope. There remains a need for standardized, comprehensive assessments of its proximate composition to support its wider application in diet and health. Early findings have shown that *Sida acuta* contains a respectable amount of crude protein, ranging from 12% to 20%, depending on environmental conditions and processing methods (Okoli *et al*., 2012). Its fiber content also appears relatively high, suggesting it could aid digestion and serve as roughage in animal feed. Furthermore, its low fat and moderate carbohydrate levels make it suitable for dietary plans targeting weight management or cardiovascular health. These findings hint at *Sida acuta*'s potential role in developing countries as a supplementary food source or animal feed ingredient, especially during periods of feed scarcity.

This research seeks to build on existing knowledge by thoroughly analyzing the proximate composition of *Sida acuta*, offering a clear and scientifically grounded understanding of its nutritional profile. The outcomes could guide its integration into broader nutritional frameworks and encourage further studies on its safety, digestibility, and long-term health effects in both humans and animals.

It is an inevitable fact that increasing research on medicinal plants could pave the way for the discovery of novel therapeutic agents against many diseases that are outstanding diseases (Perumalsam *et al*., 2019), which threatened human existence. Interestingly, World Health Organization (WHO) has recognised the significance of traditional medicine in the health-care sector and has assessed that approximately eighty percent of the population living in the developing countries depend on herbal medicines for their primary health care requirement. There are many plants in the tropical countries that have not been harnessed, knowing their Phyto-profile will help to enable many people to be attracted to their usefulness as a result of their Phyto-properties (Negash *et al*., 2017).

Sida acuta (broom weed) is one of the plants with medicinal potential qualities and present in abundance in the tropics. It is drought resistance tropical weeds that are common in almost everywhere (Asimi*et al*., 2016). *Sida acuta* is an erect, branched and perennial shrub with a woody tap root, hairy branded up to 1 m high and is reproduced from their seeds. The stem is woody, rounded and slender, and is fibrous and hairy especially when young. The leaves are simple and alternate while the inflorescence is solitary and axillary with stalks up to 1.3 cm long jointed about half of the length. The flowers are yellow with five petals and the fruit is capsuled with 5-6 carpels (Ekpo and Etim, 2009).

Sida acuta is found in the Southern Part of Nigeria where it is of highly medicinal importance where a poultice of the leaves is used as an anti – inflammatory agent in the treatment of boils. The leaves and stem are used for the treatment of many ailment including fever, aches and pains, inflammation, worm infestation, ulcer and gastro intestinal disorders. It is also used by traditional birth attendants (TBAS) to quicken delivery (Asimi *et al*., 2016). In southern part of Nigeria, *S. acuta* is a commonly used weed in rural communities mainly for the treatment of liver disorders and skin infections (Ekpo and Etim, 2009). Local/indigenous names include Udo (Igbo), Iyeye (Yoruba), Nsukerra (Efik) and Tsadarlamarudu (Hausa). It has also been used as anti- inflammatory and hypoglacaemic agent (Okwuosa *et al*., 2011).

Proximate composition can be described as the term used in the field of animal science or feed analysis to means the six components of feed for the animal that are of major or commonly important which are moisture, crude protein, ether extract, crude fiber, crude ash and nitrogen free extracts and they are usually expressed in percentages. Proximate compositions are very important in the formulation of animal diet in other to estimate the value of what the farmer is given to his or her animals. Also for any non-conventional ingredients to be used in animal feeding or as supplement, the proximate needs to be established (Shittu and Alagbe, 2020). According to Raimi *et al*., (2014) plants are basic source of knowledge in our today medicine. Most of the feed given to animal are from plant kingdom, this make it so important to know the profile of all the plant around to harnessed their importance. They reported proximate, phytochemical and micronutrient composition of *S. acuta*. With increasing health challenges, the traditional use of herbal medicine has been brought to the fore. The use of *S. acuta* has been attributed to the presence of biological active compounds in the plants.

Understanding the nutritional potential of underexplored plants like *Sida acuta* begins with evaluating their proximate composition. This type of analysis involves determining the basic nutritional content of a substance, including its moisture, ash, crude protein, lipid, fiber, and carbohydrate levels. These parameters are essential not only in food and feed formulation but also in assessing the health benefits and industrial utility of plant materials (Aremu *et al*., 2011).

The growing body of research into *Sida acuta* suggests that it possesses a wide range of bioactive compounds, including flavonoids, alkaloids, tannins, and phenolics, many of which contribute to its antioxidant, antimicrobial, and anti-inflammatory properties (Nworu *et al*., 2010). However, beyond its pharmacological profile, the plant's nutritional content has also begun to attract attention. Several studies have reported that various parts of *Sida acuta*, particularly the leaves and stems, contain appreciable levels of protein and fiber, which are crucial for human and animal health (Okoli *et al*., 2012).

Moreover, in resource-constrained settings, especially across Sub-Saharan Africa and parts of Asia, plants like *Sida acuta* offer a low-cost, locally available source of nutrients. Their inclusion in diets or as supplements in livestock feed could significantly enhance nutritional intake without the high costs associated with commercial feed and imported foods. However, before such plants can be safely and effectively incorporated into food systems, their nutritional content must be scientifically validated through comprehensive proximate analysis (Edeoga *et al*., 2006).

Fig. 1.1: *Sida acuta* Plant

Source: Srinivasan and Murali, (2022)

1.2 Statement of the Problem

Despite the abundance and wide geographical distribution of *Sida acuta*, it remains largely underutilized, often dismissed as an invasive weed with little to no economic or nutritional value. This perception persists even in communities where the plant grows profusely and where malnutrition, food insecurity, and limited access to animal feed persist as pressing issues. While *Sida acuta* has been recognized for its ethnomedicinal properties, its nutritional potential has not been fully explored or documented in a standardized, scientific manner.

The lack of comprehensive data on the proximate composition of *Sida acuta* presents a gap in knowledge that limits its integration into local food systems or animal feed formulations. Without detailed information on its nutritional components, such as protein, fiber, fat, ash, and carbohydrate contents, it is difficult to assess its true value as a dietary supplement or sustainable resource. Additionally, the absence of such data impedes further research on how environmental factors, maturity stages, or processing methods might influence its nutritional profile.

As food insecurity and the search for cost-effective, local food and feed alternatives continue to challenge many developing regions, it becomes imperative to assess and validate underutilised plants like *Sida acuta* for potential inclusion in nutritional programs. Ignoring the scientific evaluation of such plants may result in the continued underutilisation of valuable natural resources that could support human and animal health.

1.3 Justification for the Study

This study is justified by the urgent need to diversify the sources of nutrition available to vulnerable populations, particularly in regions grappling with poverty, malnutrition, and poor agricultural productivity. *Sida acuta*, being a widely available and fast-growing plant, represents a potentially sustainable and low-cost alternative source of nutrients. By scientifically evaluating its proximate composition, this research aims to offer a credible basis for its inclusion in food, feed, or even pharmaceutical applications.

Several previous studies have hinted at the pharmacological potential of *Sida acuta*, yet few have offered detailed insights into its nutritional composition using rigorous proximate analysis. Unlocking this data could support its application in livestock feeding, where there is a growing demand for locally sourced and affordable feed ingredients. Moreover, with the rising interest in plant-based diets and functional foods, understanding the nutritional profile of *Sida acuta* could reveal its utility in promoting health and wellness.The study is also justified by its potential to contribute to the scientific body of knowledge on wild and underutilised plants, promoting biodiversity conservation and encouraging sustainable use of natural resources. If validated as nutritionally rich, *Sida acuta* could shift from being a neglected species to a strategic crop in local agriculture, especially in resource-limited settings.

1.4 Aim and Objectives of the Study

The main aim of this study is to evaluate the proximate composition of *Sida acuta* to determine its nutritional potential and assess its suitability for use in human nutrition and animal feed.

Objectives of the Study:

- To determine the moisture content of *Sida acuta* in order to assess its freshness, shelf life, and suitability for storage and processing.
- To analyse the crude protein contents of *Sida acuta*, which is essential for evaluating its potential as a source of dietary protein.
- To estimate the crude fat content of the plant, which contributes to energy value and nutritional balance.
- To quantify the crude fiber content, which has implications for digestive health and feed formulation.
- To determine the ash contents, representing the total mineral contents and contributing to the assessment of its micronutrient value.

CHAPTER TWO

LITERATURE REVIEW

2.1 *Sida acuta*

Sida acuta, commonly referred to as broomweed, is a fast-growing shrub belonging to the Malvaceae family and is widely distributed across tropical and subtropical regions. Traditionally, it has been employed in various indigenous medicinal practices to treat ailments such as fever, wounds, and inflammation. However, beyond its ethnomedicinal uses, *Sida acuta* is gaining attention in scientific communities for its nutritional potential. Several studies have been conducted to evaluate the plant's proximate composition, with findings suggesting it could serve as an important source of essential nutrients and minerals, particularly in regions where food insecurity and malnutrition are prevalent (Shittu and Alagbe, 2020).

Moisture contents is a vital component in determining the shelf-life and storage capacity of plant materials. Low moisture content in plant matter generally implies extended preservation potential. According to Adegoke *et al*., (2013), the moisture contents of *Sida acuta* leaves was found to be 9.03%, indicating low water activity and high stability against microbial spoilage. Conversely, Enin *et al.,* (2014) reported a much higher moisture content of 54.82% in their analysis, suggesting that the plant’s moisture levels may vary significantly depending on environmental factors, harvesting time, or processing methods. Such discrepancies highlight the need for standardised procedures in analysing and storing the plant for food or medicinal use.

The protein content of *Sida acuta* positions it as a potential supplementary protein source, especially in regions where animal-based proteins are expensive or inaccessible. Adegoke *et al*. (2013) reported a crude protein value of 19.13%, while Shittu and Alagbe, (2020) found a similar protein concentration of 18.01% in their study. These values are comparable to those found in conventional leafy vegetables like amaranth and spinach. Given the high demand for affordable plant-based proteins, *Sida acuta* could contribute significantly to dietary protein intake, supporting muscle development, tissue repair, and overall metabolic function.

Crude fat content in *Sida acuta* has been observed to be relatively low, which is advantageous for individuals adhering to low-fat diets. Adegoke *et al*., (2013) recorded a fat content of 0.67%, while Shittu and Alagbe, (2020) reported 1.77%. Such low levels are beneficial in preventing diet-related chronic conditions such as obesity, cardiovascular diseases, and hyperlipidemia. The presence of fat, though minimal, also plays a role in the absorption of fat-soluble vitamins and the maintenance of cellular structures.

Fiber is another key nutritional component that plays a vital role in digestion and maintaining gut health. Crude fiber content in *Sida acuta* was found to be 9.50% by Adegoke *et al*., (2013) and 6.24% by Shittu and Alagbe (2020). These values suggest that *Sida acuta* can aid in enhancing bowel movements, regulating blood sugar levels, and reducing cholesterol levels. Including such fiber-rich plants in daily meals could help mitigate the risks of constipation, type 2 diabetes, and heart disease.

The ash contents, which indicates the total mineral content, also reflects the nutritional quality of *Sida acuta*. Adegoke *et al*., (2013) reported an ash content of 6.33%, implying that the plant is moderately rich in essential minerals such as calcium, magnesium, and potassium. These minerals are crucial for bone development, nerve function, and enzymatic activities. Therefore, *Sida acuta* may help supplement mineral deficiencies, especially in malnourished populations.

In terms of carbohydrates, *Sida acuta* contains a significant amount. Adegoke *et al*. (2013) recorded a carbohydrate concentration of 55.30%, making the plant a potentially good source of energy. Carbohydrates serve as the body's primary fuel, and energy-dense plants like *Sida acuta* could be of great value in food programs aimed at combating hunger. Furthermore, Shittu and Alagbe, (2020) calculated an energy value of 2760 Kcal/kg for the plant, emphasizing its potential as a high-calorie dietary component, particularly in regions experiencing food scarcity.

The important of plants of various types cannot be over emphasised. Since the time immemorial, plant has been taking so important in various approaches. Several plant leaves are delicacy in the preparation of stew in some tribes, which when its number and types is not complete the stew look awkward and unacceptable to them. The belief is that different plant contributes different nutrient to the stew which make it delicious and nutritional. Therefore, plenty plants of proven nutritional/ medicinal quality are of important to many pharmaceutical companies manufacturing a wide range of allopathic medicines, due to their phytochemical properties. This has caused increasing consideration of natural drug to an individual and most companies producing most synthetic drug (Shittu and Alagbe, 2020).

Sida acuta (broom weed) is one of the plants with medicinal potential qualities and present in abundance in the tropics. It is drought resistance tropical weeds that are common in almost everywhere. *Sida acuta* is an erect, branched and perennial shrub with a woody tap root, hairy branded up to 1 m high and is reproduced from their seeds. The stem is woody, rounded and slender, and is fibrous and hairy especially when young. The leaves are simple and alternate while the inflorescence is solitary and axillary with stalks up to 1.3 cm long jointed about half of the length. The flowers are yellow with five petals and the fruit is capsuled with 5-6 carpels (Ekpo and Etim, 2009).

Sida acuta is a malvaceous weed that frequently dominates improved pastures, waste and disturbed places roadsides (Mann *et al*., 2003). The plant is native to Mexico and Central America but has spread throughout the tropics and subtropics. In traditional medicine, the plant is often assumed to treat diseases such as fever, headache, skin diseases, diarrhea, and dysentery. Referring to the traditional knowledge, studies have been carried out to confirm the activities the plant is assumed to exert *in vivo*. The described pharmacological properties of the plants involve the antiplasmodial, antimicrobial, antioxidant, cytotoxic activities and many other properties. Some studies resulted in the isolation of single compounds while the others just demonstrated the activity of the crude extracts (Simplice *et al*., 2007).

2.1.1 Medicinal Properties of *Sida acuta*

The bark is smooth, greenish, the root is thin, long, cylindrical and very rough; leaves are lanceolate, the flowers are yellow, solitary or in pairs; seeds are smooth and black. In Indian traditional medicine, the root of *Sida acuta* is extensively used as a stomachic, diaphoretic and antipyretic. It is regarded as cooling, astringent, tonic and useful in treating nervous and urinary diseases and also disorders of the blood, bile and liver (Khare *et al*., 2002). It is also used to treat gonorrhoea, elephantiasis and ulcers and is claimed to have aphrodisiac properties. The juice of the root is applied to wound. The whole plant is used to treat snake bite and it lessened the haemorrhagic effect of Bothropsatrox venom (Sreedevi *et al*., 2009). The ethanol extract of S. acuta whole plant exhibited moderate anti-ulcer activity in ulcer models in rats (Malairajan *et al*., 2006). The ethanol extract of S. acuta leaf also exhibited antiulcer activity in ulcer models in rats (Akilandeswari *et al*., 2010). The methanol (MeOH) extract of *Sida cordifolia* aerial parts demonstrated significant antiulcer activity in an aspirin plus ethanol-induced ulcer model in rats, as reported by Philip *et al.,* (2008). Antiulcer activity of S acuta leaf extract advocates the traditional use of the plant leaf in gastric disorders and ulcers (Dinda *et al*., 2015).

Sida acuta has wide applications, in Nigeria in folk medicine. Some herbalists have claimed the use of this plant traditionally to cure infections and ailments such as fever, ulcer, gonorrhea, malaria, and breast cancer following inflammations and wound infections. The described pharmacological attribute of the plant includes antioxidant, antimicrobial, anti-inflammatory and several others (Mbajiuka *et al.*, 2014). The leaf part of the plant is the most commonly and frequently used against various diseases (Shittu and Alagbe, 2020).

S. acuta is widely distributed in pantropical areas and is widely used as traditional medicine in many cases. The plant is also used for spiritual practices. Table 1 displays the traditional usages of the plant in some regions where it grows. Among illnesses the plant is used to cure, fever is the most cited. The administration may be by oral route for example in the case of fever or by external application of the paste directly on the skin for skin diseases or snake bites. The plant may be used alone or in combination with other plants according to the diseases or to the healers (Karou *et al.*, 2007)

Table 1: Traditional Usages of *Sida acuta* in Several Regions

Locality	Local name	Used part	Traditional usages
Guatemala, Nicaragua	-	WP	Asthma, renal inflammation, colds, fever, headache, ulcers and worms
ndia (Ghats)	Pillavalattichedi	WP	Fever, bronchitis, ulcer, diarrhea, dysentery, skin diseases. The paste of leaves is mixed with coconut oil and applied on head regularly for killing dandruffs and also for strengthening hair
Kenya (Digo)	Mbundugo	WP	The plant is used to prepare "Bundugo", a supplementary strength magically added to a person
Nigeria malaria,	Iseketu	WP, L	ulcer, fever, gonorrhea, abortion, breast cancer, poisoning, inflammation, feed for livestock, stops bleeding, treatment of sores wounds antipyretic
Togo	-	L	Eczema, kidney stone, headache
Western Colombia	-	WP	Snakebites
Burkina Faso (Mossi Central Plate)	Zon-Raaga	WP	Fever, diarrhea, pulmonary affection, snakebites, insects' bites. Paste of leaves mixed with salt is applied on

			skin to cure panaris

-: non available data, L: leaves, R: roots, WP: whole plant

Source: Karou *et al*., (2007)

Since *S. acuta* has several usages in folk medicine it has been involved in many other pharmacological screenings. The plant has been screened for its cancer chemopreventive properties by Jang *et al*., (2003). The study resulted in the isolation of several compounds, among them quindolinone, cryptolepinone and 11-methoxyquindoline was found to induce quinone reductase activity, while cryptolepinone, ntransferuloyltyramine exhibited a significant inhibition of 7, 12-dimethylbenz-[a]anthracene-induce preneoplastic lesions in mouse mammary organ culture model. These observations suggested that cryptolepinone was a potential chemopreventive agent.

The polyphenol extract of the plant was tested together with polyphenol extract of other medicinal plants for antioxidant activity through free radical scavenging. The tests were performed using the phosphomolybdenum reduction and the ABTS radical cation decolorization assays with trolox as standard antioxidant. The results showed that there was a good correlation between the two methods (r = 0.9) and S. acuta had a weak free radical scavenging according to values recorded with bark extracts of K. Senegalensis, P. erinaceus and C. micranthum in the same study. The activities were highly correlated with the total phenolic content determined by the Folin-Ciocalteu reagent, with gallic acid as standard (r = 0.94 and r = 0.91 with the two assays respectively) (Karou *et al*., 2007).

In another study, Otero *et al*., (2000) showed that the ethanolic extract of the plant had a moderate activity against the lethal effect of Bothropsatrox venom. In Western Kenya where the plant is consumed as legume, a study using Brine shrimp lethality tests revealed that the plant was toxic. The author concluded that the plant can cause acute or chronic toxicities when consumed in large quantities or over a long period of time (Orech *et al*., 2005). Malairajan *et al*., (2006) had demonstrated the analgesic properties of the whole plant extract in animal model. The authors conducted the tests using two methods the hot plate method described by Woolfe and Mac Donalds (1944) and the tail immersion method described by Dykstra and Woods (1986). The screening did not result in the isolation of single compounds but the authors suggested that the observed analgesic activity may be due to steroidal compounds the plant contains (Figure 2.1).

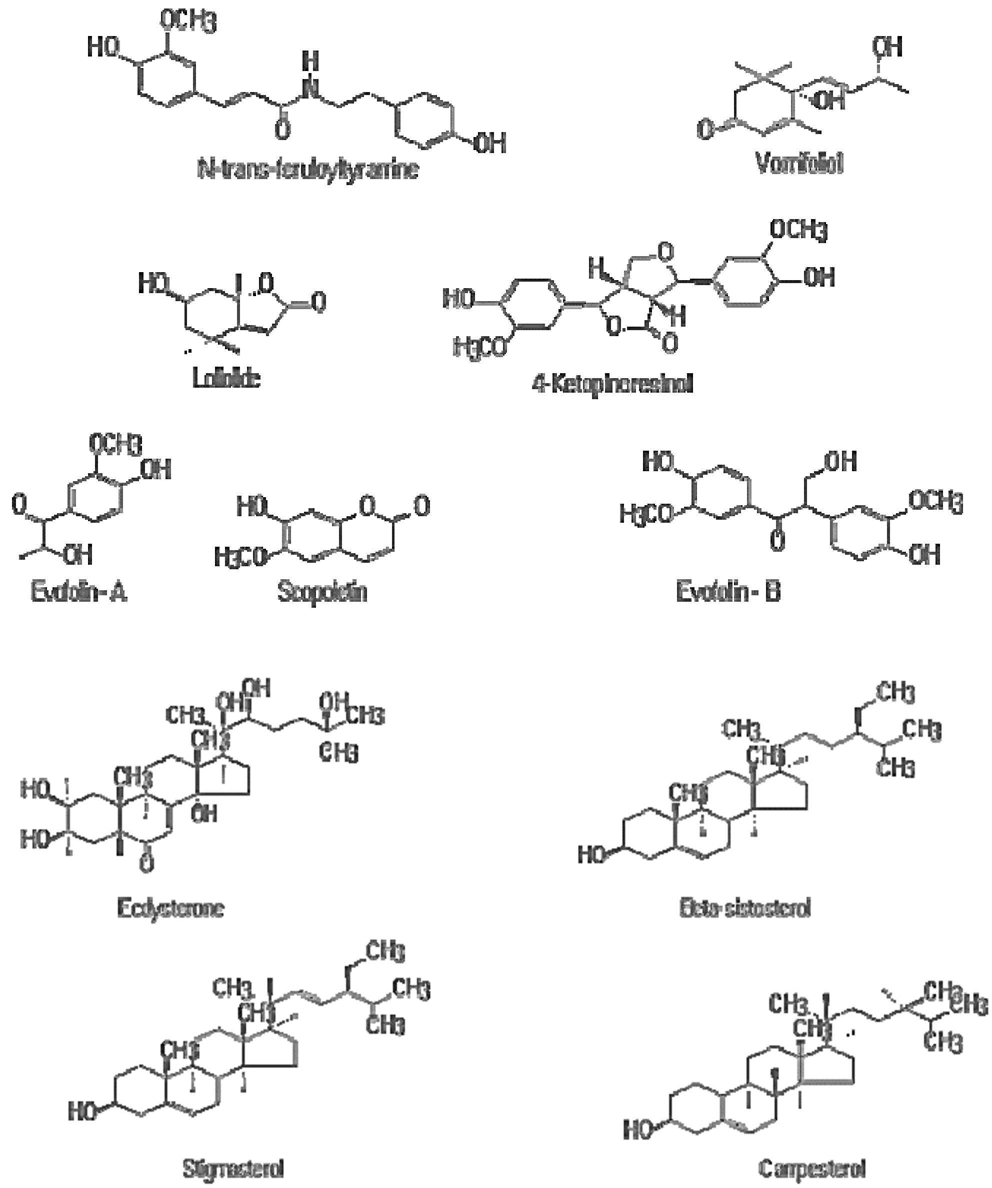

Fig. 2.1: Chemical Structure of Compounds Isolated from *S. acuta*

Source: Karou *et al.*, (2007)

2.1.2 Other Ethnomedicinal and Therapeutic Uses of *Sida acuta*

Beyond its nutritional profile, *Sida acuta* has a rich history of use in traditional medicine across various cultures. The plant is employed in the treatment of a wide range of ailments, attributed to its broad-spectrum pharmacological activity. In West African ethnomedicine, the plant is commonly used for treating fevers, wounds, and gastrointestinal disturbances. Its anti-inflammatory and antimicrobial effects are well documented, with extracts from the leaves and roots showing activity against *Staphylococcus aureus, Escherichia coli*, and *Salmonella typhi*. This supports its traditional use in managing bacterial infections and skin conditions (Idu *et al*., 2010).

The plant also exhibits notable anti-malarial activity. In traditional settings, decoctions from the leaves are administered to manage malaria symptoms, an application supported by studies showing that alkaloids and flavonoids in the plant interfere with *Plasmodium* parasites (Asase *et al*., 2005). Its analgesic and antipyretic properties further validate its role in fever management. In Ayurvedic and Indian folk medicine, *Sida acuta* is used as a cardiotonic, diuretic, and nervine tonic. It is believed to strengthen the body, improve circulation, and calm the nervous system (Kirtikar and Basu, 2006). Additionally, the plant is employed for treating dysentery, toothache, rheumatism, and urinary tract infections. Recent pharmacological investigations have also shown its hepatoprotective, antidiabetic, and antioxidant activities, suggesting potential applications in managing chronic metabolic diseases. This positions *Sida acuta* as a valuable candidate for drug discovery and development in herbal medicine (Pimple *et al*., 2007).

2.1.3 Nutritional Implications of *Sida acuta* and Relevance to Pharmacology and Dietary Use

Sida acuta, a fast-growing shrub widely distributed in tropical and subtropical regions, is not only utilized for its ethnomedicinal properties but also holds significant nutritional potential. As a leafy vegetable and herbal remedy, it contains a variety of macronutrients and phytochemicals that support both dietary and therapeutic applications. From a nutritional standpoint, *Sida acuta* is known to contain moderate to high levels of carbohydrates, crude protein, and essential minerals, including calcium, iron, and potassium, making it a viable supplementary food source, particularly in resource-limited settings (Akinmoladun *et al*., 2010). These nutrients play crucial roles in maintaining immune function, muscle development, and enzymatic processes. The presence of dietary fiber in its leaves also aids digestion and can assist in the management of blood sugar levels (Alabi *et al*., 2016).

Pharmacologically, the nutrient-rich composition of *Sida acuta* enhances the bioavailability and activity of its therapeutic compounds. For instance, the plant contains flavonoids, alkaloids, phenolics, and saponins, which exhibit antioxidant, anti-inflammatory, and hepatoprotective properties (Sofowora, 2008). These compounds are supported by the nutritional matrix of the plant, suggesting that consumption of *Sida acuta* as part of the diet could contribute to the prevention of oxidative stress-related disorders. Furthermore, *Sida acuta* has demonstrated potential for addressing micronutrient deficiencies, especially in rural populations where access to diverse food sources is limited. Its mineral content, particularly iron and calcium, can help combat anemia and bone-related conditions. When used as a decoction or infusion, the plant not only contributes to hydration but also offers therapeutic effects due to the solubility of many bioactive components in water (Omotayo *et al.,* 2017)

2.1.4 Comparison with Other Medicinal Plants

Phytochemical Composition: Like many medicinal plants, *Sida acuta* contains a wide spectrum of bioactive compounds such as alkaloids, flavonoids, tannins, saponins, and phenolics. This composition is comparable to plants like *Azadirachtaindica* **(neem)** and ***Ocimum gratissimum*** (African basil), both of which are rich in antimicrobial and antioxidant compounds (Ezekwesili *et al.,* 2004; Iwu, 1993). However, *Sida acuta* shows a higher content of alkaloids and sterols, which are particularly effective in analgesic and anti-inflammatory actions (Pimple *et al.,* 2007).

Therapeutic Activities: In terms of therapeutic effects, *Sida acuta* displays strong **antibacterial**, **anti-inflammatory**, **antidiabetic**, and **hepatoprotective** properties. These effects are comparable to those observed in **Moringa oleifera**, another widely used medicinal plant. While *Moringa* is acclaimed for its high vitamin and mineral content, *Sida acuta* is particularly potent in managing microbial infections and oxidative stress, as seen in several in vivo and in vitro studies (Akinmoladun *et al.,* 2010; Asase *et al.,* 2005).

Additionally, *Sida acuta* has shown promising **anti-malarial** and **antioxidant** effects, which are traditionally attributed to Artemisia annua and Carica papaya extracts. Although the antiplasmodial activity of sida acuta may be moderate compared to Artemisia, it still holds relevance in rural herbal practices, particularly where access to antimalarial drugs is limited (Ajayi *et al.*, 2009).

Nutritional Benefits: From a nutritional standpoint, Sida acuta contains a balanced proportion of proteins, carbohydrates, and minerals, positioning it as both a medicinal and functional food plant. This aligns it with Solanum nigrum (black nightshade) and Amaranthusviridis, which are traditionally consumed for both nourishment and health benefits in many African and Asian communities (Omotayo *et al.*, 2017; Alabi *et al.*, 2016).

Toxicity and Safety: Compared to some other medicinal plants, Sida acuta exhibits a relatively **low toxicity profile** at therapeutic doses. For example, while plants like Cassia occidentalis and Jatropha curcas can be toxic if improperly used, Sida acuta has been shown to have minimal adverse effects when administered in controlled doses, both in animal studies and ethnobotanical practice (Nworu *et al.*, 2011).

2.2 Proximate Composition

Proximate composition refers to the analysis of the major nutritional constituents in food and biological materials, typically including moisture, crude protein, crude fat, crude fiber, ash (mineral content), and nitrogen-free extract, which is primarily composed of carbohydrates. This foundational analysis provides insight into the nutritional value, digestibility, and overall quality of food substances (Nwankpa *et al*., 2015). It serves as a baseline assessment in food science, animal nutrition, and phytochemical studies, helping researchers and nutritionists evaluate the potential of various substances, including plants, for dietary or medicinal use. For example, protein levels indicate the potential for supporting tissue growth and repair, while fiber content is linked to digestive health and glycemic control. Ash content reflects the presence of essential minerals like calcium, potassium, and magnesium, vital for metabolic and structural functions in the body (Adewumi *et al*., 2023). Proximate analysis is therefore a key step in determining whether a plant like *Sida acuta* can be recommended as a food supplement or therapeutic agent, especially in resource-limited settings where nutritional deficiencies are common.

Proximate analysis is used to estimate the relative amounts of protein, lipid, water, ash and carbohydrate in any sample. Proximate composition is the term usually used in the field of feed/food and means the components of moisture, crude protein, ether extract, crude fibre, crude ash and nitrogen-free extracts, which are expressed as the content (%) in the sample, respectively. Protein, lipid and carbohydrate each contributes to the total energy content of an organism, while water and ash only contribute mass (Parimelazhagan and Thangaraj, 2016).

2.2.1 Moisture Contents

Moisture content is an essential factor in determining the storage and preservation characteristics of plant materials. It directly affects the stability and nutritional quality of plants, influencing their shelf life and susceptibility to microbial spoilage. For *Sida acuta*, a plant commonly utilised in traditional medicine and as a food supplement, understanding its moisture content is crucial for effective post-harvest handling and processing (Moti *et al*., 2020).

The moisture content in *Sida acuta* leaves has been reported to be relatively high. For instance, a study by Moti *et al*. (2020) found that the fresh leaves of *Sida acuta* contained approximately 75.2% moisture, which is typical of many leafy plants. This high moisture content makes the plant vulnerable to rapid spoilage if not properly dried or stored. Adequate drying is critical to preserving the plant's bioactive compounds and extending its shelf life for both medicinal and nutritional purposes. Similarly, Akinmoladun *et al*. (2016) recorded the moisture content of *Sida acuta* at around 74.5%, reinforcing the necessity of proper post-harvest processing techniques to reduce water activity and avoid the growth of fungi or bacteria. When dried, *Sida acuta* can be preserved effectively, making it suitable for preparation in herbal teas, powders, or extracts. However, the high moisture content in its fresh state implies that careful handling is necessary to maintain both its medicinal efficacy and nutritional value (Akinmoladun *et al*., 2016; Moti *et al*., 2020).

2.2.2 Crude Protein

Crude protein is an essential component in the nutritional evaluation of plant materials, as it reflects the total protein content, including both true proteins and non-protein nitrogen compounds. As an important macronutrient, protein plays a vital role in tissue repair, enzyme activity, immune function, and overall growth. Research on the crude protein content of *Sida acuta* indicates that it is a reasonable source of plant-based protein. According to Moti *et al.* (2020), the crude protein content in *Sida acuta* leaves was found to be approximately 12.3% on a dry weight basis. This value places *Sida acuta* among moderate protein-containing leafy vegetables, which is important for supporting protein intake in plant-based diets. Similarly, Akinmoladun *et al.*, (2016) found that the leaves of *Sida acuta* contained 11.5% crude protein, which is consistent with the general range found in other leafy plants commonly used in herbal medicine and traditional food.

The presence of crude protein in *Sida acuta* highlights its potential as a supplementary protein source, especially in regions where animal protein is scarce or expensive. Although the protein content in *Sida acuta* may not be as high as in legumes or animal-based sources, it still contributes meaningfully to the protein intake of individuals consuming it regularly. Additionally, the plant's protein is complemented by other essential nutrients, making it a valuable part of a balanced diet or herbal remedy. However, as with many plants, the quality of protein in *Sida* *acuta* depends on the availability of essential amino acids, which may vary based on cultivation and preparation methods (Akinmoladun *et al*., 2016; Moti *et al*., 2020).

2.2.3 Crude Ash

Crude ash content is a key indicator of the total mineral content in a plant material. It represents the inorganic residue left after the combustion of the plant material, and it includes essential minerals such as calcium, magnesium, potassium, phosphorus, and trace elements. While high crude ash content is often linked with a rich mineral composition, For *Sida acuta*, crude ash content has been studied to evaluate its mineral composition and overall nutritional profile. According to Singh *et al.*, (2019), the crude ash content of *Sida acuta* leaves was found to be 7.1% on a dry weight basis. This value indicates that the plant contains a significant proportion of minerals, which could contribute to its nutritional and medicinal properties. In a similar study, Oyetayo *et al.*, (2018) reported that *Sida acuta* leaves contained 6.3% crude ash, further supporting its status as a plant rich in essential minerals.

The presence of a relatively high crude ash content in *Sida acuta* suggests that it may be a useful source of minerals, particularly for individuals seeking to supplement their mineral intake through plant-based foods. However, it is important to note that while crude ash reflects the overall mineral content, the bioavailability of these minerals can vary depending on factors such as soil composition, plant age, and preparation methods. Therefore, further studies on the specific mineral profiles and their absorption rates would be beneficial for understanding how *Sida acuta* can best be used in dietary applications (Singh *et al*., 2019; Oyetayo *et al*., 2018).

2.2.4 Lipid

Lipids are an essential class of biomolecules that play key roles in energy storage, cellular structure, and signaling processes within the human body. In plants, lipids are primarily found in the form of oils and fats, which are important for their role in cellular function and energy storage. Research on the lipid content of *Sida acuta* indicates that while the plant does contain lipids, the levels are generally moderate. According to Oyeleke *et al*., (2021), the crude lipid content of *Sida acuta* leaves was found to be around 3.2% on a dry weight basis. This is relatively low compared to oil-rich plants like soybean or sunflower, which have lipid contents above 20%. However, this level of lipids is still significant for a plant traditionally consumed as a leafy green or used in herbal medicine. In addition to providing energy, the lipids in *Sida acuta* may offer additional health benefits. Some studies suggest that the lipids in medicinal plants contain essential fatty acids, such as omega-3 and omega-6, which play important roles in reducing inflammation, supporting cardiovascular health, and promoting proper brain function (Akinmoladun *et al*., 2017). However, further research is necessary to fully assess the specific types of fatty acids present in *Sida acuta* and their bioactivity.

Though *Sida acuta* is not typically regarded as a major source of lipids, its moderate lipid content, when combined with its other nutritional components, contributes to the plant's overall value as a functional food and medicinal herb. Its lipid content, along with its high mineral and protein content, suggests that it could have synergistic benefits when included in a balanced, plant-based diet (Oyeleke *et al.*, 2021; Akinmoladun *et al.*, 2017). Crude fat is the term used to refer the crude mixture of fat-soluble material present in a sample. Crude fat also known as the ether extract or the free lipid content is the traditional measure of fat in food products. The lipid materials may include triglycerides, diglycerides, monoglycerides, phospholipids, steroids, free fatty acids, fat-soluble vitamins, carotene pigments and chlorophylls. The common approach for total crude fat determination is based on the solubility of lipids in non-polar organic solvents such as hexanes, petroleum ether or supercritical liquid carbon dioxide with or without a solvent modifier (Arunachalam *et al*., 2011)

2.2.5 Crude Fibre

Crude fibre, or dietary fibre, refers to the indigestible parts of plant materials, including cellulose, hemicellulose, and lignin, which are essential for digestive health. Fibre plays an important role in maintaining gastrointestinal function, regulating blood sugar levels, and supporting cardiovascular health. The crude fibre content in *sida acuta* has been examined in several studies, revealing notable levels of dietary fibre. According to Akinmoladun *et al*. (2017), the crude fibre content in the leaves of *Sida acuta* was found to be approximately 14.4% on a dry weight basis. This value indicates that *Sida acuta* is a moderate source of fibre, which is beneficial for promoting healthy digestion and preventing constipation. Additionally, dietary fibre is known to play a role in weight management by promoting satiety, which could enhance *Sida acuta*'s role as part of a balanced diet.

In a similar study, Oyeleke *et al*., (2021) reported that the crude fibre content of *Sida acuta* was 13.8%, further supporting its relevance as a plant-based source of fibre. Given the plant's use in traditional medicine and as a food supplement, its moderate fibre content could be advantageous for individuals seeking to improve their digestive health or regulate their cholesterol levels. Fibre-rich plants such as *Sida acuta* are also thought to contribute to overall gut health by supporting the growth of beneficial gut bacteria (Oyeleke *et al*., 2021). Though *Sida acuta* is not as high in fibre as some other plants like legumes or root vegetables, its significant fibre content, combined with its medicinal properties, contributes to its overall value in both dietary and therapeutic contexts. The presence of fibre, along with other bioactive compounds, makes *Sida acuta* a valuable plant in traditional and modern herbal medicine (Akinmoladun *et al*., 2017; Oyeleke *et al*., 2021).

2.2.6 Carbohydrate Content

Carbohydrates are vital organic molecules that serve as the primary energy source for most living organisms. They play an essential role in metabolic pathways and biological functions, including energy storage, structural support, and cellular communication (Chandrasekara and Kumar, 2016). In plants, carbohydrates not only contribute to their nutritional value but also influence their pharmacological efficacy, particularly when used in traditional medicine. Carbohydrate content can be calculated by difference, using the formula:

Carbohydrate (%) =100− [% Moisture+% Protein+% Fat+% Ash+% Fiber]

This method ensures that the total proximate composition sums up to 100%, and it has been extensively applied in the nutritional profiling of herbal and food plants (AOAC, 2016). In several studies, *Sida acuta* has been reported to contain a relatively high carbohydrate content, which contributes to its caloric value and its potential as a supplementary food source. For instance, Olayemi *et al*., (2011) found that the dried leaves of *Sida acuta* contained approximately 45.6% carbohydrate. This is consistent with findings by Oyedepo *et al.*, (2016), who reported carbohydrate levels ranging between 42.7% and 50.3%, depending on the part of the plant analysed and the drying method used. These values indicate that *Sida acuta* has a moderate to high carbohydrate content when compared with other leafy medicinal plants.

Additionally, Edeoga, Okwu, and Mbaebie (2005), reported carbohydrate levels around 44% in their analysis of *Sida acuta*, further supporting its nutritional significance. The high carbohydrate content also suggests that the plant may have good energy-yielding potential and could be utilised in addressing nutritional deficiencies in rural communities where it is commonly consumed as a leafy vegetable or herbal tea. Apart from its nutritional importance, carbohydrates in *Sida acuta* may act as synergists in phytotherapeutic actions, helping to enhance the bioavailability of active compounds such as flavonoids, alkaloids, and saponins

(Okwu and Josiah, 2006). Furthermore, the water-soluble sugars present can contribute to osmotic regulation and antioxidant capacity in the plant tissues (Siddhurajuand Becker, 2003).

2.2.7 Applications of Proximate Composition Data

Proximate composition analysis is a fundamental tool in nutritional, agricultural, and pharmacological sciences. It provides quantitative data on the basic constituents of biological materials, typically including moisture, crude protein, crude fat (lipid), ash (mineral content), crude fiber, and carbohydrates. These data serve a wide range of practical and research purposes across multiple disciplines (Chandrasekara and Kumar, 2016).

1. Nutritional Assessment and Food Value Determination

One of the most important applications of proximate composition is in the **nutritional evaluation** of food and medicinal plants. By quantifying essential nutrients such as protein, carbohydrates, and fat, proximate data help determine the **energy content** and **nutritional adequacy** of a food item. This is especially crucial for underutilized or traditional plant foods like *Sida acuta*, which are commonly used in rural and indigenous diets (Chandrasekara and Kumar, 2016).

2. Comparative Analysis of Edible Plants

Proximate data enables researchers to perform **comparative studies** of different plants or plant parts, guiding consumers and food processors toward healthier or more efficient dietary choices. For example, comparing the protein or fiber content of several leafy vegetables allows for better selection in nutrition-sensitive interventions (Edeoga *et al*., 2005).

3. Formulation of Animal Feed and Food Products

In agricultural industries, proximate composition is vital for the **formulation of livestock feeds** and **processed food products**. Knowledge of nutrient content ensures that dietary requirements of animals or target populations are met (AOAC, 2016).

4. Quality Control and Standardisation

Proximate analysis serves as a **quality control tool** for processed food, pharmaceuticals, and herbal formulations. For medicinal plants, consistency in proximate composition ensures **standardisation**, a crucial step in establishing dosage accuracy, safety, and therapeutic efficacy (Okwu and Josiah, 2006).

5. Shelf-Life Prediction and Storage Decisions

Moisture content data, in particular, plays a key role in determining the **shelf life and storage stability** of food products. High moisture levels are linked with microbial spoilage, while dry products tend to last longer. This information informs **storage, packaging**, and **preservation strategies** (Siddhuraju and Becker, 2003).

6. Baseline for Advanced Chemical and Functional Studies

Proximate composition data often serve as a **foundation for deeper phytochemical, biochemical, or functional analyses**. For instance, a plant high in protein or lipid content might be further investigated for the presence of essential amino acids or unsaturated fatty acids (Olayemi *et al*., 2011).

7. Economic Evaluation of Plant Resources

Plants that exhibit rich proximate profiles can be promoted as **alternative food sources or commercial crops**, contributing to food security and rural income. The economic potential of underutilized species can be gauged from their nutrient density (Oyedepo *et al*., 2016).

2.2.8 Factors Affecting Proximate Composition

The proximate composition of plant materials, including moisture, protein, fat, ash, fiber, and carbohydrate content, can be influenced by a variety of **biological, environmental, and methodological factors**. Understanding these factors is essential for the accurate interpretation and comparison of compositional data (Siddhuraju and Becker, 2003).

1. Genotypic Variability

Different plant species and even cultivars within the same species can show significant variation in proximate composition due to genetic differences. This variability affects nutrient biosynthesis and accumulation patterns (Chandrasekara and Kumar, 2016).

2. Environmental Conditions

Environmental factors such as **soil type, rainfall, temperature, and altitude** play a crucial role in nutrient uptake and metabolism. For instance, protein and carbohydrate contents may vary significantly based on the availability of nitrogen and other soil nutrients (Siddhuraju and Becker, 2003).

3. Maturity and Harvesting Time

The stage of plant maturity greatly affects its nutrient profile. Young leaves may contain more moisture and less fiber, while mature plants tend to accumulate more carbohydrates and lignified fiber. Delayed harvesting can also lead to nutrient losses (Edeoga *et al*., 2005).

4. Post-Harvest Handling and Storage

Exposure to sunlight, air, or microbial activity during storage can degrade sensitive nutrients, especially proteins and fats. Moisture content can also fluctuate with humidity and temperature changes, impacting the dry matter basis of proximate values (Olayemi *et al*., 2011).

5. Processing Methods

Processes like drying, boiling, fermentation, and grinding influence nutrient composition. For example, sun drying may reduce vitamin content, while oven-drying can concentrate nutrients by removing more water (Oyedepo *et al*., 2016).

6. Analytical Methods and Accuracy

Different laboratories may use slightly different methods (e.g., AOAC, ISO), leading to variations in measured values. Additionally, sample preparation techniques and instrument calibration influence the accuracy of the results (AOAC, 2016).

2.2.9 Challenges in Proximate Analysis

Despite its widespread application, proximate analysis comes with several **technical and practical challenges** that can compromise the reliability and reproducibility of results.

1. Sample Heterogeneity

One of the foremost challenges is the **non-uniform nature of plant materials**, which may contain varying amounts of stems, leaves, or roots. Ensuring a representative and homogenized sample is essential for accurate analysis (Okwu and Josiah, 2006).

2. Moisture Content Variability

Moisture determination is particularly sensitive to **environmental humidity**, sample handling, and drying temperature. Over-drying may lead to the loss of volatile compounds, while under-drying can lead to falsely elevated moisture values (AOAC, 2016).

3. Protein Determination Limitations

The most common method for protein estimation (Kjeldahl method) assumes a fixed nitrogen-to-protein conversion factor (usually 6.25), which may not be accurate for all plants, especially those with non-protein nitrogen (Edeoga *et al*., 2005).

4. Fiber and Ash Estimations

Determining crude fiber may **underestimate total dietary fiber**, as it does not account for soluble fibers. Ash determination may also include non-nutrient elements like silica or environmental contaminants, skewing mineral content estimates (Siddhuraju and Becker, 2003).

5. Equipment Sensitivity and Human Error

Analytical instruments such as ovens, spectrophotometers, and balances require **regular calibration**. Small inaccuracies or improper reagent preparation can significantly affect the results (Chandrasekara and Kumar, 2016).

6. Time and Labour Intensiveness

Proximate analysis can be **time-consuming and labor-intensive**, especially in laboratories with limited resources. Multi-step processes increase the chance of procedural errors, especially where automation is not available (Olayemi *et al*., 2011).

CHAPTER THREE

MATERIALS AND METHODS

This chapter outlines the materials and methods used to assess the hepatoprotective and anti-ulcerogenic effects of *Sida acuta* leaf extract on Wistar rats with indomethacin-induced gastric ulcers. The study includes plant material preparation, phytochemical screening, proximate and mineral analyses, antioxidant property evaluation, and an experimental design to evaluate liver function and gastric protection. Standardized protocols ensure reproducibility and scientific validity.

3.1 Materials

3.1.1 Plant Material

Fresh leaves of *Sida acuta* were collected from Ilorin, Kwara State, Nigeria, in December, 2025. The plant was authenticated at Fulcrum Innovation Limited, Ilorin. Leaves were air-dried at room temperature for 14 days, pulverized into a fine powder using a mechanical grinder (Nigeria), and stored in airtight containers until analysis.

3.1.2 Animal Material

Adult abino rats (90–186g, 11–22 weeks old) were obtained from the Animal House, Fulcrum Innovation Limited, Ilorin. Rats were acclimatized for 14 days under standard conditions (12-hour light/dark cycle, 25 ± 2°C, 50–60% humidity) with access to standard pellet feed and water *ad libitum*. The study was approved by the Fulcrum Innovation Limited, Ilorin.

3.1.3 Chemicals and Reagents

All chemicals were analytical grade, sourced from Fulcrum Innovation Limited, Ilorin, including:

- Indomethacin (≥99%) for ulcer induction.
- Omeprazole (≥98%) as the standard anti-ulcer drug.
- Ethanol (95%) for extraction.
- Phytochemical reagents: Wagner's reagent, Fehling's solution, Folin-Ciocalteu reagent, aluminum chloride.
- Antioxidant assay reagents: 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS), ferric chloride, Trolox, ascorbic acid.
- Liver function test kits: Alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), total protein (Randox Laboratories, UK).

3.2 Methods

3.2.1 Preparation of the Plant Extract

The 500g of powdered *Sida acuta* leaves were macerated in 2.5 L of 90% ethanol for 72 hours at room temperature with intermittent stirring. The mixture was filtered through Whatman No. 1 filter paper, and the filtrate was concentrated using a rotary evaporator at 40°C under reduced pressure. The crude ethanolic extract was left in the laboratory for concentration to constant weight and stored at 4°C. The yield was calculated as:

$$\text{Percentage Yield (\%)} = \frac{\text{Weight of crude extract}}{\text{Weight of powdered plant material}} \times 100$$

Yield Example: If 500 g of powder yielded 50 g of extract, the yield is:

$$\text{Percentage Yield} = \frac{50}{500} \times 100 = 10\%$$

3.2.2 Determination of Antioxidant Properties

The assessment of antioxidant properties in indomethacin-induced ulcerogenic rats treated with *Sida acuta* extract focuses on key biochemical markers that reflect liver function and oxidative stress. These methods are designed to evaluate the extract's potential to mitigate oxidative damage and support hepatic health.

3.2.2.1 Determination of Moisture Content

Moisture was determined by the loss in weight that occurs when asample is dried to a constant weight in an oven. 2g of a Cheese sample was weighed into a silica dish previously dried and weighed. The sample was then dried in an oven for 65°C for 36 hours, cool in a desiccator and weighed. The drying and weighing continued until a constant weight was achieved.

$$\% \text{ Moisture} = \frac{\text{Wt of sample + dish before drying} - \text{wt of sample+ dish after drying}}{Wt of sample taken} \text{x}100$$

Since the water content of feed varied widely, ingredients and feed are usually compared for their nutrient content on moisture free or Dry Matter (DM) basis.

% DM = 100 - %Moisture.

3.2.3.2 Determination of crude protein

Crude protein was determined by measuring the nitrogen content of the feed and multiplying it by a factor of 6.25. This factor is based on the fact that most protein contains 16% nitrogen. Crude protein was determined by kjeldahl method. The method involves: Digestion, Distillation and Titration.

Digestion: 2 g of the sample was weighed into kjeldahl flask and 25 ml of concentrated sulphuric acid, 0.5 g of copper sulphate 5g of sodium sulphate and a speck of selenium tablet were added. Heat in a fume cupboard was applied slowly at first to prevent undue frothing, digestion continued for 45 minutes until the digester became clear pale green. It was left until completely cooled and 250 ml of distilled water was rapidly added. The digestion flask was rinsed 2-3 times and the rinsing was added to the bulk.

Distillation: "Markham distillation apparathus was used for distillation. The distillation apparatus was steamed up and about 10 ml of the digest was added into, the apparatus via a funnel and allowed to boil. 10mts of sodium hydroxide was added from the measuring cylinder so that ammonia was not lost. It was distilled into 50ml of 2% boric acid containing screened methyl red indicator.

Titration: the alkaline ammonium borate formed was titrated directly with HCL. The titre value which was the volume of acid used was recorded. The volume of acid used was fitted into the formula which became:

$$\%N = \frac{14\times VA \times 0.1 \times w \times 100}{1000 \times 100}$$

% Crude protein = %N x 6.25

Where; VA= volume of acid used, w= weight of sample,

3.2.3.3 Determination of Crude Ash

Determination of Ash content of the samples: Ash is the inorganic residue obtained by burning off the organic matter of feedstuff at 400-600°C in muffle furnace for 4hours. The 2 g of the sample was weighed into a pre-heated crucible. The crucible was placed into muffle furnace at 400-600°C for 4 hours or until whitish-grey ash was obtained. The crucible was then placed in the desiccator and weighed.

$$\%ASH = \frac{wt.of\ crucible + ash - wt.of\ crucible}{wt\ of\ sample} \times 100$$

3.2.3.4 Determination of Lipid

Determination of Fat content: The ether extract of sterols represents the fat and oil in the sterols.

Soxhlet apparatus is the equipment used for the determination of ether extract. It consists of 3 major components. An extractor: comprising the thimble which holas the sample, Condenser for cooling and condensing the ether vapour and 250 ml flask.

Procedure: 150 mL of an anhydrous diethyl ether (petroleum ether) of boiling point of 40°-60°C was placed in the flask. 2-5 g of the sample was %Ether extract = weighed into a thimble and the thimble was plugged with cotton wool. The thimble with content was placed into the extractor; the ether in the flask was then heated. As the ether vapour reached the condenser through the side arm of the extractor, it condensed to liquid form and drop back into the sample in the thimble, the ether soluble substances were dissolved and were carried into solution through the siphon tube back into the flask. The extraction continued for at least 4 hours. The thimble was removed and most of the solvent was distilled from the flask into the extractor. The flask was then disconnected and placed in an oven at 65°C for 4 hours, cooled in a desiccator and weighed.

$$\text{\% ether extract } \frac{\text{weight of flask + extract} - \text{tare weight of flask}}{Wt\ of\ sample} \text{x}100$$

3.2.3.5 Determination of Fibre

The organic residue left after sequential extraction of feed with ether can be used to determine the crude fibre, however if a fresh sample was used, the fat in it could be extracted by adding petroleum ether, stirred and allowed to settle and decanted. This was done three times. The fat-free material was then transferred into a flask/beaker and 200 ml of pre-heated 1.25% H_2SO_4 was added and the solution was gently boiled for about 30mins, maintaining constant volume of acid by the addition of hot water. The Buckner flask funnel fitted with Whatman filter was pre-heated by pouring hot water into the funnel. The boiled acid sample mixture was then filtered hot through the funnel under sufficient suction. The residue was then washed several times with boiling water (until the residue was neutral to litmus paper) and transferred back into the NaOH beaker. Then 200 ml of pre-heated 1.25% NaSO was added and boiled for another 30 minutes. Filtered under suction and washed thoroughly with hot water and twice with ethanol. The residue was dried at 65°C for about 24 hours and weighed. There sidue was transferred into a crucible and placed in muffle furnace (400-600°C) and ashed for 4 hours, then cooled in desiccator and weighed.

3.2.3.6 Determination of Carbohydrate Contents

The 2 grams of the powdered sample was weighed, refluxed with 20 mL 80% ethanol for 30 minutes (for water-soluble carbohydrates). The extract was filtered using Whatman No. 1 filter paper. 0.2 mL of the plant extract was pipetted into a test tube and 1 mL of 5% phenol was added. Quickly, 5 mL of concentrated sulfuric acid was also added. The absorbance was measured absorbance at 490 nm and compared with the standard glucose curve to determine carbohydrate content.

Calculation

The standard curve was used to determine the concentration of carbohydrate in the extract. Then:

$$\text{Carbohydrate content}\left(\frac{\text{mg}}{\text{g}}\right)=\frac{\text{Concentration (mg/mL)}\times\text{Total Volume (mL)}}{\text{Weight of Sample (g)}}$$

CHAPTER FOUR

RESULTS

4.1 Proximate Composition of *Sida acuta*

The results of the proximate composition for samples A1 and A2 of *Sida acuta* are presented below. Both samples exhibited similar nutritional profiles, with slight variations across parameters, suggesting either minor experimental variability or biological diversity between the samples.

Table 4.1: Proximate Composition of *Sida acuta*

S/N0	Sample	Crude Protein (%)	Crude Lipid (%)	Moisture Content (%)	Total Ash (%)	Crude Fibre (%)	Carbohydrate (%)
		13.57	7.14	8.24	11.42	28.37	31.16

4.1.1 Moisture Content

Moisture content, a key factor in food shelf-life and microbial stability, was found to be 8.08% in A1 and 8.40% in A2. These low values suggest that the samples were adequately dried, which is beneficial for storage, packaging, and preservation. Lower moisture content reduces the likelihood of microbial growth and degradation, enhancing the shelf stability of plant materials intended for industrial or medicinal use. Moti *et al*., (2020) found that the fresh leaves of *Sida acuta* contained approximately 75.2% moisture, which is typical of many leafy plants. Similarly, Akinmoladun *et al*., (2016) recorded the moisture content of *Sida acuta* at around 74.5%, reinforcing the necessity of proper post-harvest processing techniques to reduce water activity and avoid the growth of fungi or bacteria. When dried, *Sida acuta* can be preserved effectively, making it suitable for preparation in herbal teas, powders, or extracts. Comparison of the results in this study and literatures reveals that the moisture content of *Sida acuta* under study is relatively low.

4.1.2 Crude Protein

In terms of **crude protein**, samples A1 and A2 recorded values of 13.56% and 13.78%, respectively. This indicates moderate protein content, positioning *Sida acuta* as a potential plant-based protein source. Protein is essential for growth, tissue repair, enzyme synthesis, and overall metabolic function. For a wild leafy plant, protein levels above 10% are considered appreciable, and this reinforces the nutritional significance of *Sida acuta*, especially in areas with limited access to animal-based protein sources.This results correlate with that of Moti *et al*. (2020), who reported crude protein content in *Sida acuta* leaves to be approximately 12.3%

4.1.3 Crude Ash

The **ash content** was 11.39% in A1 and 11.44% in A2. Unlike the report of Singh *et al*., (2019), found the crude ash content of *Sida acuta* leaves to be 7.1% indicating that the plant contains a significant proportion of minerals, which could contribute to its nutritional and medicinal properties. Similar study by Oyetayo *et al*., (2018) reported that *Sida acuta* leaves contained 6.3% crude ash, further supporting its status as a plant rich in essential minerals. High ash content in the samples under study indicates a substantial presence of minerals, which may include calcium, potassium, magnesium, iron, and other trace elements. These minerals play vital roles in bone health, electrolyte balance, and metabolic enzyme function. This supports the ethnopharmacological application of *Sida acuta* in managing conditions linked to mineral deficiencies.

4.1.4 Lipid Content

The **crude lipid** content was recorded at 7.07% in A1 and 7.21% in A2. These values are relatively high for a non-oil seed plant. Lipids, although required in smaller quantities compared to carbohydrates and proteins, serve important biological roles including energy provision, cellular structure integrity, and transport of fat-soluble vitamins (A, D, E, and K). The fat content also contributes to the caloric density of the plant, making it a potential energy source in feed formulations. Crude lipid content result reported by Oyeleke *et al*., (2021), shows that *Sida acuta* leaves has 3.2% lipid content. This is relatively low compared to the samples under study.

4.1.5 Crude Fibre

Crude fibre values were notably high, with 29.22% in A1 and 27.52% in A2. Unlike the findings of Oyeleke *et al*., (2021) who reported that the crude fibre content of *Sida acuta* was 13.8%, further supporting its relevance as a plant-based source of fibre and also, Akinmoladun *et al*. (2017) reported the crude fibre content in the leaves of *Sida acuta* to be approximately 14.4% on a dry weight basis. This result reveals that the fibre content of the pant under study is relatively high compared to the reported studies. Fiber is a non-digestible component of plant matter that aids in maintaining healthy bowel movements, preventing constipation, and reducing risks of colon-related diseases. While high fiber content is desirable for human digestion and metabolic health, in animal feed, excessive fiber may affect digestibility and nutrient absorption, especially in monogastric animals. However, for ruminants and herbivores, such fiber levels may be advantageous.

4.1.6 Carbohydrate Content

Carbohydrate content, calculated by difference, was 30.68% in A1 and 31.64% in A2, making it the most abundant macronutrient in both samples. Similarly, the findings of Olayemi *et al*., (2011) who reported that the dried leaves of *Sida acuta* contained approximately 45.6% of carbohydrate content. Also, Oyedepo *et al*., (2016), who reported carbohydrate levels ranging between 42.7% and 50.3%, indicating that *Sida acuta* has a moderate to high carbohydrate content when compared with other leafy medicinal plants. Carbohydrates serve as the primary energy source for biological functions and physical activity. A significant proportion of carbohydrates in *Sida acuta* further support its potential as a calorie-contributing food source.

The relatively low moisture content observed in both samples (A1: 8.08%, A2: 8.40%) demonstrates effective drying, which is critical for preventing microbial degradation and ensuring long-term preservation. This contrasts sharply with moisture levels reported in fresh leaves by Moti *et al.,* (2020) and Akinmoladun *et al.,* (2016), which exceeded 74%. The low moisture values suggest that the studied samples underwent appropriate dehydration, making them suitable for storage in powdered or dried herbal formulations. Protein content, measured at 13.56% (A1) and 13.78% (A2), indicates that *Sida acuta* could contribute meaningfully to dietary protein intake, especially in resource-poor settings where plant-based protein sources are vital. These values exceed or align with those in previous studies and emphasize the plant's potential utility in combating protein-energy malnutrition.

Lipid content in this study (7.07% and 7.21%) was notably higher than values previously reported (e.g., 3.2% by Oyeleke *et al.*, 2021). Although *Sida acuta* is not primarily recognized as an oil-yielding plant, this finding suggests potential as a supplementary lipid source. Lipids are essential for numerous physiological functions, including the absorption of fat-soluble vitamins and cellular membrane integrity. Ash content, representing total mineral composition, was also considerably high (11.39% and 11.44%). This strongly implies that *Sida acuta* is rich in essential minerals such as calcium, magnesium, and iron—minerals often deficient in many diets. The ash content exceeds those previously reported by Singh *et al.,* (2019) and Oyetayo *et al.,* (2018), underscoring the plant's mineral-rich nature.

One of the most remarkable findings is the very high crude fibre content (29.22% and 27.52%). These values nearly double those previously reported by researchers, confirming *Sida acuta* as a potent source of dietary fibre. This has implications for digestive health, cholesterol reduction, and metabolic regulation. Lastly, carbohydrate levels (30.68% and 31.64%) position carbohydrates as the most abundant macronutrient in the samples. Although lower than those reported in some previous studies, the current values still indicate a substantial energy contribution, which further supports the plant's use in caloric supplementation.

4.2 Implications of Findings

Nutritional Use: The moderate to high levels of protein, carbohydrates, and fibre in *Sida acuta* make it a valuable supplement for diets deficient in macronutrients. This supports its inclusion in herbal diets, functional foods, and nutritional formulations.

Pharmaceutical and Ethnomedicinal Value: High ash and crude fibre contents support the plant's role in traditional medicine, especially for treating mineral-deficiency diseases and improving gut health.

Animal Feed Potential: Due to its high fibre and energy content, *Sida acuta* may be a useful roughage supplement in ruminant diets, although its high fibre levels could limit digestibility in monogastric animals unless properly processed.

Industrial Application: The low moisture content enhances the shelf life and stability of the plant material, making it ideal for use in powdered herbal preparations, teas, and nutraceutical products.

CHAPTER FIVE

DISCUSSION

The proximate composition of *Sida acuta* has been comprehensively carried out, providing valuable insights into the nutritional potential of the plant. Analysis of two samples (A1 and A2) revealed a consistent nutritional profile, with slight variations attributable to biological or environmental factors. The study confirms that *Sida acuta* is a nutritionally rich wild leafy plant, with significant implications for its use in food, herbal medicine, and animal feed applications. The key findings are as follows:

Moisture Content: The moisture content was relatively low in both samples (A1: 8.08%, A2: 8.40%), indicating that the plant material was adequately dried. This low moisture level enhances shelf stability and reduces the risk of microbial spoilage, making the plant suitable for long-term storage and formulation in dried products such as powders, teas, or extracts.

Crude Protein: Moderate protein levels were observed (A1: 13.56%, A2: 13.78%), highlighting *Sida acuta* as a promising plant-based source of protein. This is particularly relevant in areas where access to animal protein is limited, and it supports the potential inclusion of the plant in diets aimed at addressing protein-energy malnutrition.

Crude Lipid: The lipid content was relatively high for a non-oil seed plant (A1: 7.07%, A2: 7.21%), suggesting that *Sida acuta* can contribute to dietary fat intake.

This provides additional energy and facilitates the absorption of fat-soluble vitamins (A, D, E, and K), enhancing its nutritional value.

Total Ash: High ash content (A1: 11.39%, A2: 11.44%) indicates a rich mineral composition. This supports the plant's traditional use in ethnomedicine and suggests it could help meet micronutrient requirements, particularly in mineral-deficient populations.

Crude Fibre: The plant exhibited very high crude fibre levels (A1: 29.22%, A2: 27.52%), which is beneficial for maintaining healthy digestion and bowel function. This high fibre content makes it especially valuable in dietary plans focused on gut health, and it may also be suitable for inclusion in ruminant animal feed formulations.

Carbohydrate Content: Carbohydrates were the most abundant macronutrient in the samples (A1: 30.68%, A2: 31.64%), positioning *Sida acuta* as a reliable energy source. This adds to the plant's appeal as a potential dietary component in energy-boosting food products.

5.1 Conclusion

The findings from the proximate composition analysis of *Sida acuta* samples reveal that the plant possesses a rich and diverse nutritional profile, supporting its relevance not only in traditional medicine but also in modern nutritional and industrial applications. The study establishes that *Sida acuta* contains appreciable levels of crude protein, fibre, lipids, ash (minerals), and carbohydrates, all essential components for maintaining physiological and metabolic balance in both humans and animals. The relatively low moisture content recorded in both samples indicates that the drying methods employed were effective in preserving the integrity of the plant, which is particularly important for shelf-life stability and microbial resistance. This supports its long-term use in dried or powdered forms such as teas, supplements, or pharmaceutical preparations.

The moderate protein levels found in this study further emphasize the plant's potential as a supplementary protein source, especially in developing regions where access to animal protein may be limited. When combined with its high carbohydrate content, *Sida acuta* becomes a reliable source of energy, offering dual nutritional benefits. This macronutrient balance makes the plant an important candidate for dietary incorporation. The remarkably high fibre content not only underscores the plant's gastrointestinal benefits but also suggests its suitability in weight management diets and in reducing risks associated with cardiovascular and metabolic disorders. Furthermore, this high fibre characteristic may find applications in animal nutritionparticularly for ruminants that benefit from fibrous forage. The ash content reflects a substantial presence of essential minerals, which could enhance the body's metabolic and enzymatic functions, thus validating its historical use in ethnomedicine. The relatively high lipid content, uncommon in many leafy plants adds an additional layer of nutritional and caloric value, especially in formulations where fat-soluble vitamin absorption is critical.

The study presents *Sida acuta* as a multi-purpose plant with potential for use in food systems, therapeutic applications, and animal feed industries. The observed values surpass many previously reported compositions in literature, highlighting the influence of geographical, seasonal, and environmental factors on nutrient availability. These findings thus support the need for further investigations into the phytochemical, mineral, and pharmacological properties of the plant to unlock its full potential. Ultimately, this study provides a scientific foundation for the continued use and possible commercialization of *Sida acuta*, encouraging its incorporation into integrated health, nutrition, and agricultural frameworks.

5.2 Recommendations

- **Nutritional Programs**: *Sida acuta* should be integrated into community-level nutritional intervention programs, especially in rural or low-income regions, as a natural source of dietary protein, fibre, and minerals.
- **Phytochemical and Mineral Analysis**: Further studies should focus on detailed phytochemical profiling and mineral content determination to identify specific compounds responsible for its therapeutic effects.
- **Toxicological Studies**: Comprehensive toxicological evaluations are necessary to establish safety thresholds and potential side effects of long-term or high-dose use.

- **Product Development**: The plant could be explored for the development of functional foods, dietary supplements, and herbal formulations aimed at improving digestive health and nutritional status.
- **Animal Nutrition**: Its suitability as a feed additive, particularly for ruminants, should be evaluated further through feeding trials to optimize inclusion levels and determine digestibility.
- **Standardization and Cultivation**: Cultivating *Sida acuta* under controlled conditions could help standardize its nutritional content, improve availability, and facilitate commercial utilisation.

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